Elastic tube motion in 3D vascular-mimicking network

Team 8

Mingzhang Zhu
Zhengqi Zhong
YaoHsing Tseng

UCLA Samueli School of Engineering

Background

- Traditional Tendon-driven continuum robots:
    - Difficult to scale down size:
        - Complex Structure
        - Slow Fabrication process
        - Cost Expensive
    - Hard to implement on surgery:
        - Large Size
        - Nonlinear Control (Multiple DOF)
        - Huge computational power needed
- Solution: Soft Continuum Robots
    - Work Environment:
        - Complex and constrained:
            - Cardiac and peripheral interventions (important soft tissues)
            - Tortuous Vascular
    - Task:
        - MIS (Minimally Invasive Surgery)
        - Cerebral Thrombosis Elimination
        - Occlusion, aneurysm in brain vascular.

Figure 1: a tendon-driven continuum robot [3]

Objective

The objective of this project is to simulate a soft continuum robot with a steerable probe navigating to a desired location within a complex vascular network.

- Three DOF
- Axial translation, axial rotation, distal bending
- 2D → 3D network
- Two driven methods for the steerable probe

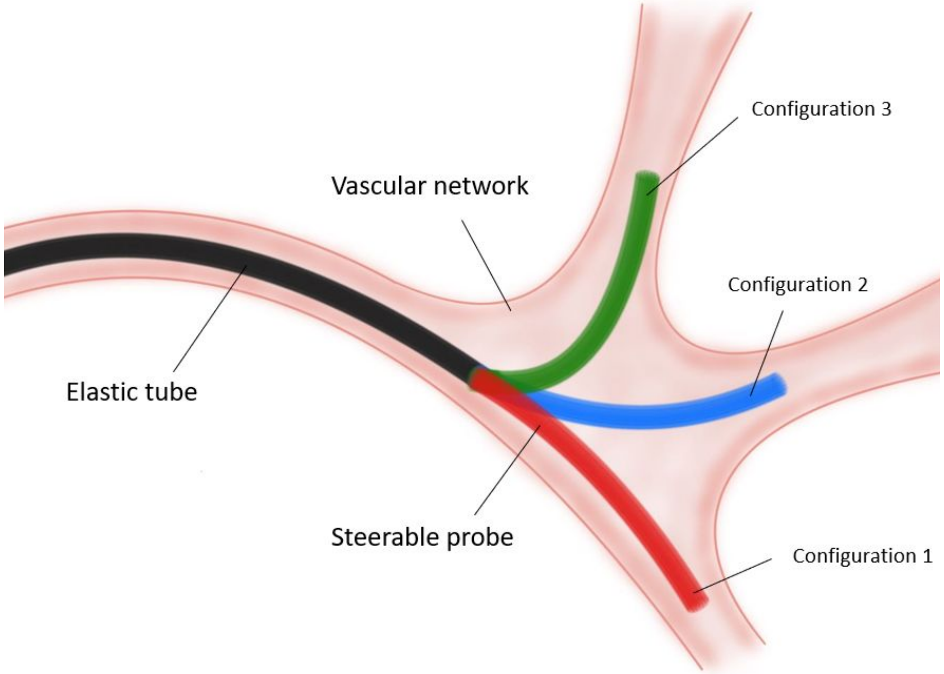

Figure 3: Illustration of an active steerable probe of a soft continuum robot navigating a complex vascular network.

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Method

- Discete Elastic Rod (DER) analysis
- Newton-Raphson iteration to solve each time step
- Active actuations → Force vectors
- Constructing a virtual physical environment
- Constructing a complex network
- Collision detection mechanisms → Friction between the robot and inwall of network

Discussion

Magnetic Driven Robot

a. Robot head is hemisphere magnet
b. Magnet can be controlled by external magnetic field
c. The head can guide the entire robot body
d. No internal energy source is needed.

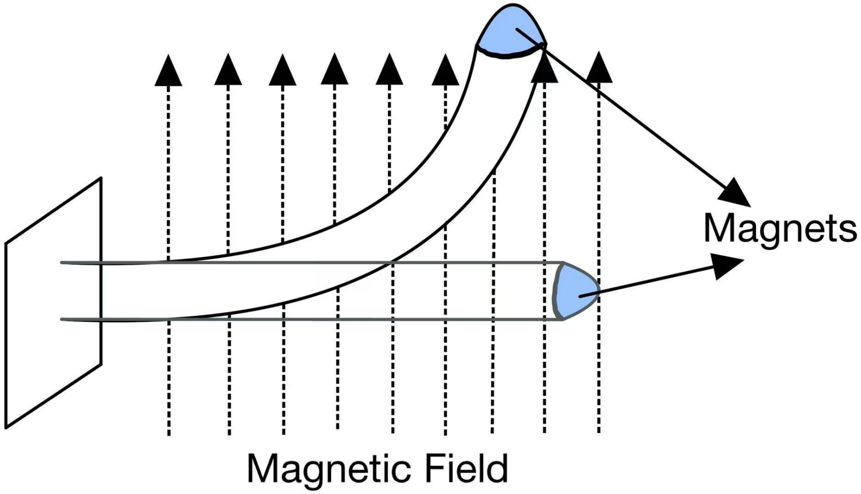

Figure 4: Magnetic Driven Robot

Steerable Probe

a. 1 DOF at Robot Head
b. Sinple Structure
c. Low energy consumption
d. Low Manufacturing Cost

Figure 5: Stearable Robot

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Project Timeline

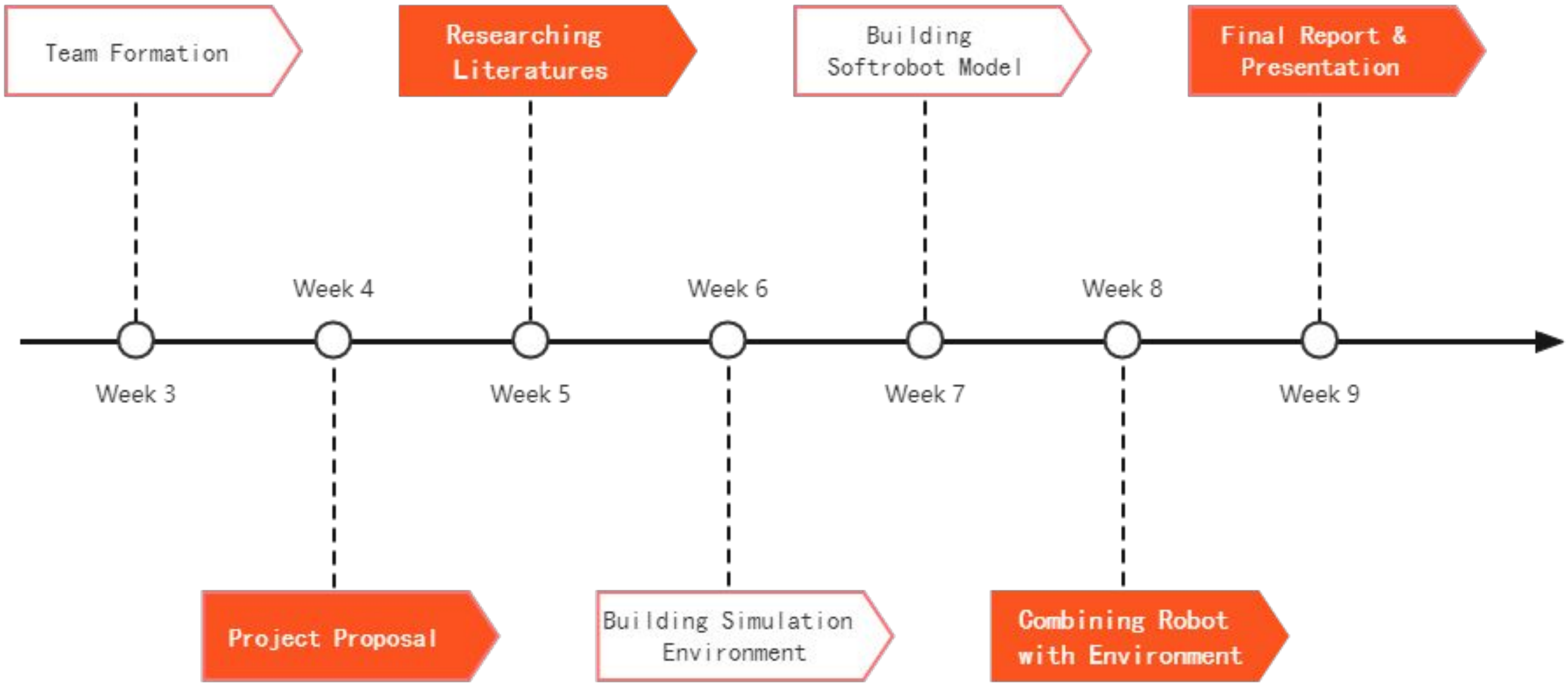

Figure 6: Project Timeline

Reference

1. Cianchetti, M., Laschi, C., Menciassi, A. et al. Biomedical applications of soft robotics. Nat Rev Mater 3, 143–153 (2018).
2. H. Rafii-Tari, C. J. Payne, G.-Z. Yang, Current and emerging robot-assisted endovascular catheterization technologies: A review. Ann. Biomed. Eng. 42, 697–715 (2014).
3. Rao, P., Peyron, Q., Lilge, S., & Burgner-Kahrs, J. (1AD, January 1). How to model tendon-driven continuum robots and benchmark modelling performance. Frontiers. Retrieved April 21, 2022, from https://www.frontiersin.org/articles/10.3389/frobt.2020.630245/full